# Experimental investigation of helical nonneutral plasmas

H. Himura, H. Wakabayashi, M. Fukao, Z. Yoshida, and Y. Ogawa

*Department of Advanced Energy, Graduate School of Frontier Sciences,*

*The University of Tokyo, 7-3-1 Hongo, Bunkyo Ward, Tokyo 113-0033, JAPAN*

M. Isobe, S. Nishimura, C. Suzuki, S. Okamura, K. Matsuoka, and H. Yamada

*National Institute for Fusion Science, 322-6 Oroshicho, Toki, Gifu 509-5292, JAPAN*

An experimental study on helical nonneutral plasmas is performed on the Compact Helical System (CHS) at National Institute for Fusion Science (NIFS), Japan. The helical nonneutral plasmas are produced with an electron gun which is placed in the stochastic magnetic layer surrounding the helical magnetic surfaces. The paper consists of three parts listed below.

**I. Penetration of electrons inside the helical magnetic field**

Remarkably, despite being launched from the outside of magnetic surfaces, electrons travel across the magnetic field **B** and penetrate deeply inside the closed surfaces. This phenomenon happens in 100 μs, while the electron-neutral collision time is about 500 μs. Thus, it indicates that the penetration of electrons is caused by a collisionless mechanism that has never been observed in past toroidal nonneutral plasmas confined in axisymmetry. Actually, fluctuation can be recognized significantly in the data of electron particle flux $\Gamma_e$ during the penetration phase, indicating the existence of collective phenomena that may bring about the inward transport of electrons.

**II. Profiles of potential and particle flux in equilibrium**

About 150 μs later, values of space potential $\phi_p$ and also $\Gamma_e$ seem to be saturated at each measurement point, suggesting an equilibrium state of helical nonneutral plasmas. Around the separatrix of helical magnetic configuration, a steep gradient of $\phi_p$ is clearly formed. The corresponding electric field **E** is calculated to be about 10 kV/m. However, around the magnetic axis, $\phi_p$ is almost constant, indicating little electrons there. In fact, the electron density inferred from $\Gamma_e$ is about $10^{11}$ m$^{-3}$ much smaller than the Brillouin density limit. As for $\Gamma_e$, a shear profile is clearly observed because of inhomogeneous **E** and **B** in the helical configuration.

**III. Disruption of the helical nonneutral plasmas**

The stable phase described above lasts for 1 - 4ms and then, starts to disrupt. About 50 kHz of fluctuation is observed in $\Gamma_e$ at the event. This frequency and the other observed parameters which are related to the onset time of the disruption suggest an ion-related instability such as the ion resonance instability as the possible mechanism.

# Confinement of non-neutral plasmas in the CNT experiment

*T. Sunn Pedersen, J. P. Kremer, A. H. Boozer, Columbia University*
*N. Pomphrey, W. Reiersen, F. Dahlgren, Princeton Plasma Physics Laboratory*

The Columbia Non-neutral Torus (CNT) is a small stellarator being built at Columbia University to study the confinement of pure electron and partly neutralized plasmas on toroidal magnetic surfaces. Equilibria of pure electron plasmas on magnetic surfaces are fundamentally different from those previously studied. In a magnetic surface configuration, positive and negative particles are confined simultaneously, allowing a systematic experimental study of plasmas with arbitrary charge neutrality, from single component to quasineutral. In a negatively charged plasma, positive particles will be very well confined by the combination of the electrostatic well and the magnetic surfaces. Hence, ion accumulation will occur on a time scale set by the ionization rate of background neutrals. Likewise, positrons will accumulate if introduced into an initially pure electron plasma. This may allow the creation of the first laboratory positron-electron plasmas.

Theoretical and numerical results for the equilibrium and confinement of non-neutral and positron-electron plasmas on magnetic surfaces will be presented. Important dimensionless physics parameters for the CNT experiment include the ratio of the parallel equilibration time to the ExB rotation time, the ratio of the ion accumulation time to the confinement time, the ratio of Debye length to system size, and the ratio of electrostatic potential energy to kinetic energy of the particles. The design and expected operating regimes of the CNT experiment will be discussed in the context of these parameters.

This work is supported by U.S. DOE Grant # DE-FG02-02ER54690

# Experimental factors limiting confinement in the Lawrence Nonneutral Torus

M. R. Stoneking, M. A. Growdon, R. T. Peterson, and D. J. Thuecks
*Lawrence University, Department of Physics, Appleton, WI 54911*

Issues of toroidal equilibrium, stability and confinement are studied in the Lawrence Nonneutral Torus (LNT), a partially toroidal electron plasma device. This paper reports on the results of experiments and hardware upgrades that shed light on the mechanisms that presently limit confinement times to about 300 μs. Although it is conceivable that intrinsically toroidal effects might limit confinement, no such mechanism known to us should result in the rapid losses we observe. The remaining suspected mechanisms involve field asymmetries (both magnetic and electrostatic) and the effects of the presence of neutral atoms (both transport due to collisions with neutrals and the catalysis of the ion resonance instability). Several pieces of evidence lead to the conclusion that field asymmetries dominate the transport in the LNT. Hardware upgrades aimed at improving field symmetry and the application of a weak vertical magnetic field correction both result in extended confinement times. On the other hand, while the presence and character of oscillations generated by the presence of ions changes with enhanced neutral pressure, the electron confinement time is relatively insensitive to either the presence of the neutrals or the ions they engender. Plans for an improved toroidal electron plasma device will also be presented.

This work is supported by U.S. Dept. of Energy and Lawrence University